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Competency-based on-the-job training for aviation maintenance and inspection – a human factors approach

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Abstract

More than 90% of the critical skills that an aviation maintenance technician uses are acquired through on-the-job training (OJT). Yet many aviation maintenance technicians rely on a 'degenerating buddy system', 'follow Joe around', or unstructured approach to OJT. Many aspects of the aviation maintenance environment point to the need for a structured OJT program, but perhaps the most significant is the practice of job bidding which can create rapid turnover of technicians. The task analytic training system (TATS), a model for developing team-driven structured OJT was developed by the author, and first introduced in Boeing Commercial Airplane Group to provide competency-based OJT for aviation maintenance and inspection personnel. The goal of the model was not only to provide a comprehensive, highly structured training system that could be applied to any maintenance and inspection task, but also to improve team coordination, attitude and morale. The first goal was accomplished by following the systems eight-step process, the latter through incorporating human factors principles such as decision making, communication, team building and conflict resolution into the process itself. In general, the process helps to instill mutual respect and trust, enhance goal-directed behavior, strengthen technicians' self-esteem and responsiveness to new ideas and encourage technicians to make worthwhile contributions. The theoretical background of the model is addressed by illustrating how the proven training methodologies of job task analysis and job instruction training are blended with human factors principles resulting in a unique team-driven approach to training, The paper discusses major elements of the model including needs identification, outlining targeted jobs, writing and verifying training procedures, an approval system, sequencing of training, certifying trainers, implementing, employing tracking mechanisms, evaluating, and establishing a maintenance/audit plan.

Relevance to industry

TATS has been successfully installed in several maintenance and inspection areas of The Boeing Company. Four major U.S. airlines – United Airlines, Trans World Airlines, Northwest Airlines, and USAirways have participated in two years of development and field testing in their maintenance operations (assisted by the author and Dr. Barbara Kanki of NASA Ames Research Center).

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1. Introduction

The task analytic training system (TATS) is an eight-step team-driven model for developing a structured on-the-job (OJT) program for aviation maintenance and inspection personnel. It is based on the proven training methodologies of job task analysis and job instruction training, and the basic human factors principles of team building, communication, decision making, and conflict resolution (Walter, 1990). TATS responds to human performance problems by not only providing a structured training system, but by providing a process that allows teams of maintenance technicians to identify and address organizational and cultural issues that interfere with work performance (Walter, 1996). These issues include relaying and standardizing information transfer during shift turnover, interactions with other organizations such as ramp crews and logistical support, and instilling team coordination both within and across organizations.

2. The aviation maintenance environment

Today most aviation maintenance operations rely on a 'degenerating buddy system', or 'follow Joe around' approach to OJT. Training is generally the responsibility of the lead mechanic who may or may not be the most knowledgeable or experienced person and who may or may not want to be involved with training. The training is generally unstructured which means that there is no written documentation of the training procedures to follow, training often is conducted away from the actual work-site, and there is no objective means to measure task performance so that all are trained to the same standard. The training is unsystematic, piecemeal, or hit and miss at best. As a result aviation maintenance technicians sometimes go through their job motions more or less by rote, without a real feel for what they are doing. When tasks are complex and hazardous, error rate increases and productivity decreases (Kello, 1989). In general, there is little consistency from technician to technician or shift to shift. Without any concrete training outlines to follow, valuable details can be left out and mistakes perpetuated. As a result, the probability of maintenance error is tremendous. Mistakes make by maintenance technicians can have disastrous results. In fact, since 1959, there have been more than 1,789 fatalities attributed to aircraft maintenance (Boeing, 1996). Research shows that unstructured on-the-job training leads to increased error rates, lower productivity and decreased training efficiency (Jacobs and Jones, 1995).

Many aspects of the aviation maintenance environment point to the need for a structured on-the-job training program, but perhaps the most significant is the practice of job bidding which can create rapid turnover in some critical areas such as engine overhaul. A primary advantage of having a structured, comprehensive training system is that technicians are trained very quickly in new skills with minimum disruption of the day-to-day schedule. Another characteristic of this environment is that many local features of the work environment affect task completion and must be taken into consideration. For example, task completion may be hindered by the need to "unlearn" old methods or by physical aspects of the workplace such as inadequate space and environmental and safety conditions. Task completion may need to accommodate frequent personnel shifts or shift changes and may run up against cross-organizational conflict including incompatibility of procedures and terminology (Walter and Kanki, 1995).

There may be a wide gap between what is specified in the airline maintenance manual procedures and what mechanics actually do, because of inaccurate or "sketchy" procedures, failure to update procedures in line with equipment changes, or simply because the prevailing norm is to not use the manuals. Since the TATS process requires the mechanics who do the job to develop the training material and requires close team cooperation, the result is better procedures and improved communication. On-site observations of maintenance technicians using the TATS program indicate that more relevant, realistic procedures seem to foster more respect for operating procedures among the technicians in general. Similarly, safety hazards, and even serious safety violations may be discovered (or rediscovered).

3. A unique team-driven approach

When teams engage in problem-solving activities directed toward task accomplishment such as developing structured on-the-job training, the team members build something together that could not have been built by a single individual. The act of building something together also builds a sense of camaraderie, cohesion, and esprit de corps. Team building occurs as a natural by-product of learning to solve problems in a group setting. Team development is basically creating the opportunity for people to come together to share their ideas and their work experiences to achieve both individual and common goals (French and Bell, 1984). TATS provides such an opportunity for team building.

Five basic assumptions of human behavior underlie the team-driven approach and are reflected in the training system (Ansbacher and Ansbacher, 1956). The first assumption is that *all human behavior is goal-directed*. Each person's primary goal is to belong and to feel significant. This striving for belonging and significance is the basis for motivation. People can only feel significant if they contribute. It is through this active contribution to the work process that individuals feel job satisfaction, and work teams sustain high morale. When workers are not given the chance to contribute, they may become counterproductive, rebellious, avoid tasks, try to sabotage the system, etc. When given the chance to contribute, they become productive, task-oriented workers. Aviation industries spend millions of dollars on training and do not realize that it is only when people feel they are contributors to a useful goal that all their potential can be directed toward that goal.

The second assumption is that *people are creative decision makers*. Having an active role in solving problems is a hallmark of job satisfaction. People who are encouraged to be creative and active participants feel they can make a difference and have an impact on the work environment. TATS uses work teams to generate solutions by having them ask questions like, 'What is the best way to do this job?' One of the assumptions of TATS is that people have the right to know what's going on around them, especially when in affects their jobs, and they should have some control over that.

The third assumption is that *human behavior occurs in a social context*. People do not operate in isolation. Everything we do, as individuals or in teams, relates in some way to other people. Most problems cannot be solved by one person in isolation. Rather, cooperation and the contribution of people resources around us solve problems. The study of human error has paid little attention to the fact that behavior is not solitary. In fact, the social dynamics of the work environment have a tremendous effect on error rates (Senders and Moray, 1991).

Fourth, *use is more important than possession*. The knowledge and skills a person has do not count unless they are put to use. In order for TATS to succeed, workers and management must commit to an attitude that values work, worker participation, and job satisfaction over and above the possession of the skills and knowledge requirements alone.

The fifth assumption is that *people and organizations function holistically*: that is, the whole is greater than the sum of its separate parts. TATS is based on maximizing the benefits of using people resources. The quality and quantity of individuals' independent work is generally not as effective as the same work accomplished cooperatively. Similarly, teams are more effective when their respective jobs are designed, analyzed and trained within a systems perspective.

Throughout TATS program development and implementation, technicians are encouraged to openly give and receive feedback on their suggested step-by-step procedures. Relationships with supervisors are emphasized as technicians address with management staff, needs and concerns that if met, lead to effectiveness, support and reinforcement. In addition to high-performing technicians, a strong sense of teamwork and high morale can develop.

4. A description of the working model

The TATS model is a generic process, a performance-based, hands-on approach applicable to any job in a variety of organizational styles. It provides comprehensive structured, on-the-job training. Human factors principles such as decision making,

communication, team building and conflict resolution are either built directly into the model or are present as a function of the techniques involved. Working elements of the model include: needs analysis; outlining targeted job(s); writing and verifying training modules; an approval system; sequencing training for individualized training; implementing; debugging; evaluating; and a maintenance/audit plan.

The system, when in operation, will:

- establish written, agreed-upon performance standards which are measurable and observable
- train and verify that workers are following established standards
- evaluate, on a regular basis, to assure, sustained performance and to initiate appropriate corrective action
- provide a plan for continuing system maintenance with an internal facilitator
- build teams, improve communication and decision making skills, and boost morale.

TATS is based on full workforce participation. During the system's development phase, key personnel are selected to carry out the process, including a design team, an approval team and a team facilitator. The design team consists of at least three content experts. Their primary task is to perform a job task analysis and write training modules on the identified tasks. The modules are short, step-by-step procedures required to perform specific tasks. Criteria used in selecting workers to serve on the design team are:

- credibility with their peers, supervisors, and staff,
- willingness and ability to communicate their beliefs,
- expertise on the jobs being analyzed,
- willingness to go along with the group even when not in total agreement.

Many design teams have included trainees and less experienced technicians, with quite amazing results. Having non-experts on the team helps to ensure the appropriate level of detail in the modules and fosters employee buy-in. One design team, while writing training modules for the task of overhauling and repairing Auxiliary Power Units (APUs), invited the vendor, technical writers from the airline, engineers from both vendor and airline, and other support personnel to join them from time to time. The members of the design team will change over time, but the design team as a unit stays intact indefinitely. TATS is an on-going process that does not stop once the original set of training modules are written and implemented. The workers are continually monitoring and evaluating the program as well as identifying new training needs.

The approval team is made up of knowledgeable technicians, key supervisors, and technical experts. They review and approve the training modules for accuracy, completeness, and compatibility with current procedures and policies. In addition, they determine the administrative requirements for implementing changes.

The facilitator functions as a process expert and is present at all design team meetings to keep the team on track, help handle disagreements, and coordinate activities. Strengthening communication links to avoid misunderstandings is a constant task for the TATS facilitator. Although not a job expert, the facilitator contributes expertise in guiding the team through the task analysis and the eight implementation steps.

5. Application of the model in the aviation environment

This training system can be used to introduce new operations or to train technicians on those already in existence. Likewise, the system can exist alone as a new training program or can be integrated easily into an existing program, including classroom training. In addition, TATS can be applied effectively in areas of high turnover, in any situation that requires technicians to be retrained, or to enhance current skills and knowledge. The design team may apply the system to critical elements alone or to the entire job. The team has ownership of the system and directs its development to answer training needs. Implementation of the system is an ongoing process. Modules are written and used as needs arise. The flexibility of the modules – short, step-by-step, "how-to" procedures – allows for tailoring training to meet individual technician needs.

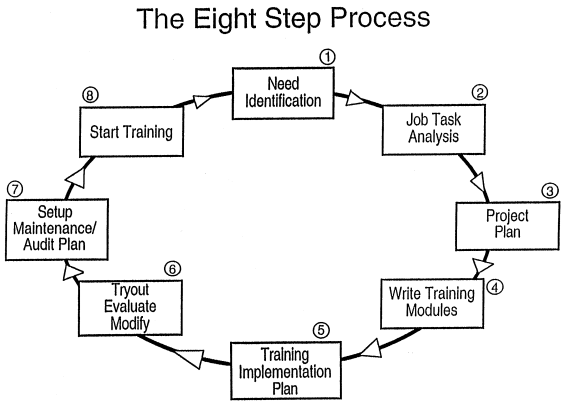

Fig. 1. The eight-step process. The TATS design teams follow the eight steps identified here in developing the structured OJT program.

5.1. *The model: the eight-step process*

Fig. 1 shows the eight-step process for installing TATS in an aviation maintenance work area. Following is a description of what occurs during each step.

5.1.1. *Step 1 – need identification*

Identification of the problem as a training concern is the first step. If technicians are able to do the job but are prevented from doing so because of organizational constraints, there is not a training problem. The decision to do OJT must be linked to a documented business issue that is caused by lack of technician knowledge, skill, or attitude. Once the need is established and a job is identified, the facilitator (normally a person from the training department) discusses the training system process with the technicians. Together they evaluate the usefulness of the system in that area. The facilitator then gains their commitment to continue.

During this initial phase, the design teams are established and the roles and responsibilities set up. Once the teams are up and running, a member of the team, someone with facilitation skills, takes over as facilitator and relieves the training department of that task. On the basis of the needs identified, this is also a good time to begin defining the measurable objectives of the program. These may include overall performance and training goals, as well as specific performance standards associated with particular tasks.

5.1.2. *Step 2 – job task analysis*

The design team conducts the task analysis, which consists of breaking the job or task into small segments or tasks by applying the following two questions:

(1) What do trainees need to know/be able to do to perform the specific job or task?
(2) Can that information be taught and learned by someone in one-half hour?

Answers to question 1 are written on wall charts by the design team facilitator. Question 2 results in further breakdown of the major tasks into smaller segments. Repeated use of the two questions ends when the team agrees that the branch of the "tree" takes no more than one-half hour to teach and learn. The job breakdown is reviewed, modified and accepted by area supervision. The flow chart in Fig. 2 illustrates the task analysis process.

One-half hour segments:

(1) fit the average attention span,
(2) provide manageable blocks of material for ease of instruction and learning,

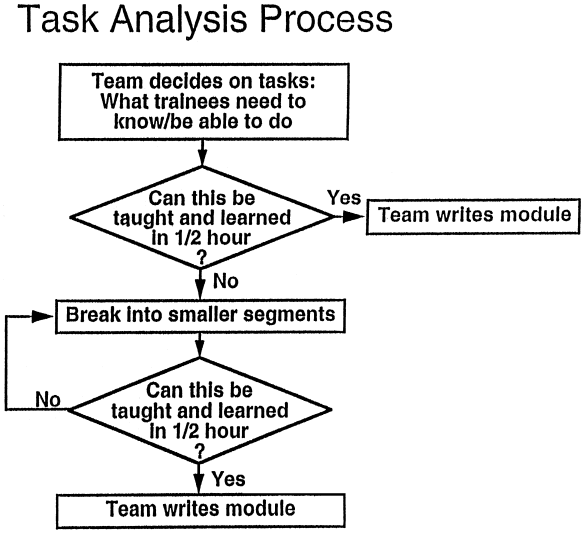

Fig. 2. Task analysis process. The TATS design teams perform task analyses or job task breakdowns until the teams decide that all tasks can be taught and learned in one-half hour. These tasks will later be written as training modules.

(3) allow flexibility in situations where operating conditions require short periods of training,
(4) may be easily modified as specifications change,
(5) give trainees a sense of accomplishment as they build a solid skill base,
(6) allow immediate and specific feedback on performance.

Design teams may choose to address only critical elements or tasks, such as engine borescope inspections, or a larger set of tasks such as the overhaul and repair of an Auxiliary Power Unit (APU) from start to finish. Structured OJT is not meant to train technicians how to do an entire job. Rather, structured OJT focuses on small components of jobs that are called tasks, or small units of job-related information. Structured OJT focuses on a strictly limited set of job-related knowledge and skills. Some design processes place task analysis before the selection of the training approach. The order is reversed here because for OJT, we assume that a task inventory is available when the process begins.

5.1.3. Step 3 – project plan

After the job breakdown is complete, the team designs a plan to keep the rest of the project on schedule. Identified tasks are ranked according to frequency, criticality, difficulty, safety concerns, etc. Some modules may need to be completed first in order to begin training on those tasks right away. A benefit of putting the project plan together as a group is the assurance of buy-in or ownership. People tend to support their own ideas. Upon completion of the plan, the team obtains supervisory approval. This helps strengthen management involvement and commitment.

The project plan is critical. Programs can fail because critical elements of the process are not identified and implemented. A clear, concise activity plan averts disaster before it strikes. Depending on the program objectives defined, the project plan may include systematic data collection in order to track specific performance and training goals.

5.1.4. Step 4 – write the training modules

Initially, two or three modules are selected in order for the team to learn the writing format. The level of complexity written into a module is critical. Too little detail means the module is unusable because of insufficient information. Too much detail results in a standard operating procedure which is cumbersome and difficult to modify. Generally, writers include enough material to serve as memory joggers for a trainer experienced doing the job. Again, having a trainee or less experienced technician on the design team proves invaluable here. The less experienced technician will provide the insight needed to make the modules most useful for training purposes. Examples of training modules are shown in Figs. 3 and 4. The easy-to-read-and-use two- column format promotes technician acceptance and increases the likelihood of the modules being used for quick task references. The facilitator does all the writing for the team and is careful to write the module so that it makes the most sense to the technicians. If questions arise as to the correct way of wording or phrasing, a technical writer may be consulted. Very rarely is this necessary.

Each module has a cover sheet with a performance objective, trainer preparation, special requirements, prerequisite modules, and the three-step job instruction training procedure discussed in step 8. The design team members who write the modules are listed as authors at the bottom of the cover sheet, further assuring ownership.

Training Module No. 24
Title: How to Perform Developer ConcentrationTest

Column 1 What	Column 2 Why, When, Where, How
1. **Locate Equipment** - cylinder, hydrometer, thermometer, temperature vs specific gravity chart	1. Storage Cabinet No. 2
2. **Clean Equipment If Required**	2. Water Rinse and Dry
3. **Perform Test**	3. A. Fill Cylinder With Developer - put on level surface
	B. Insert Hydrometer - allow it to come to a resting position
	C. Take Reading of Specific Gravity (See Module 24a.)
	D. Measure temperature of developer
	E. Find specific gravity on chart and take reading(See Module 24b.)

Fig. 3. Training module – "How to Perform Developer Concentration Test". Example of a training module in the easy-to-read-and-use two-column format.

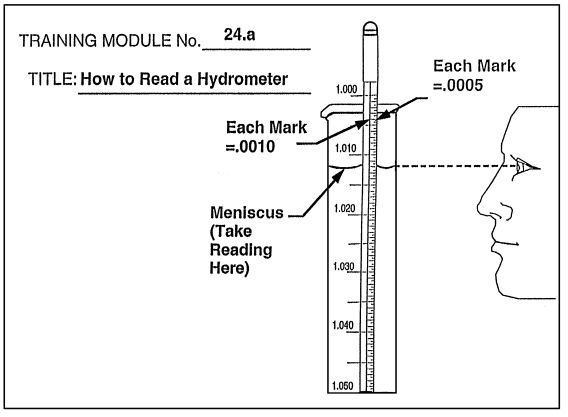

Fig. 4. Training module – "How to Read a Hydrometer". This module is a prerequisite to the module in Fig. 3 and illustrates the level of detail that teams often find necessary.

When there is more than one way to do a task, the facilitator encourages the team to select the best way for a new trainee to do the job. The team makes decisions by consensus rather than by voting so that all sides of an issue receive representation. During the writing phase, the team engages in varying activities: meeting other teams in different areas, discussing forms and formats, providing periodic reviews to management, and verifying modules on-site.

Design teams typically meet for 1 or 2 h per week in order not to interfere with normal job accomplishment. Occasionally some choose to spend several hours per week, or even full time where necessary to complete the entire writing activity. Some teams who have chosen to spend several hours a week, report that there was not enough opportunity to reflect on the tasks, and so went back to 1 or 2 h per week. Often design teams in other locations or on other shifts (who perform the same job) share in the module writing activities in order to lower the workload for any one team. This process strengthens communication between teams and helps assure buy-in once the modules are completed. Often approval teams are chosen from technicians on a different shift.

A major benefit of having teams of technicians write the training material is that it provides a very non-threatening way for experienced technicians to admit that they are not sure how to do a task or had learned the task incorrectly. Having teams of workers engaged in a task-oriented project, such as TATS, results in discussions of the best way for a trainee to perform a task, and places the focus on the trainee and not the individual team members. It's an excellent process for finding out where the knowledge and skill deficiencies are in the maintenance operations. For example, some experienced technicians were not able to explain step-by-step how to use a hydrometer to measure specific gravity. Others were not able to interpret the meaning of decimal fractions. Still others could not read simple temperature charts and take accurate readings. Some teams occasionally find it necessary to call in technical experts to answer questions about task accomplishment. Not only does a structured on-the-job training program result from the effort of the team, but the *process* works to increase the knowledge and skill base of the technicians.

In addition to developing a structured OJT program, we are also changing the organizational culture. One of the fastest ways to change organizational culture is to change group behavior (French et al.). When the group behavior changes, the group attitude changes, followed by a change in the norms and values. Finally, the individual will change. Because of an atmosphere of distrust and competitiveness in some aviation maintenance environments, the prevailing norms are to hide mistakes, not admit to others a lack of knowledge or skill, a failure to sign off on a job because it was performed incorrectly, refusal to train fellow technicians, and in some cases not wanting to be seen using the maintenance manuals. TATS changes the group behavior because the process of performing task analyses and writing training modules, forces the technicians to cooperate and share their expertise with others. It provides a 'safe' environment. Many supervisors have reported that for the first time, the three shifts are talking and discussing how to best do the job. Others teams begin to realize that the current procedures may not adequate and need to be amended. The group attitudes begin to change from one of fear and distrust to that of mutual trust and respect. Before long the norms and values change. Technicians openly give and receive information, follow procedures, and in general cooperate to get the job done.

5.1.5. Step 5 – training implementation plan

Near the completion of module writing, the team, together with supervision, prepares a preliminary implementation plan. They conduct workforce evaluations to determine: who needs training in which modules and by what dates, who will do the training, and how results of training will be measured. A technician is assigned to prepare individual plans, taking into consideration prior skills and knowledge brought to the job by trainees and a logical sequence for presenting the modules. Proper sequencing and spacing of training modules improves retention.

Integrated with the identification of trainees and the individual training plans is the selection and preparation of trainers. In addition to meeting the standard criteria for trainers, the TATS trainer must have hands-on experience with the modules. Preferably, the trainer will have served on the design team.

TATS Trainer Councils are formed to provide continuous improvement of the entire TATS process. The Trainer Council is a group of three or more OJT trainers who meet once a month for the purposes of improving the efficiency and effectiveness of OJT and to assure that the resultant training and performance standards will continue to encourage a sense of teamwork as a result of the training itself. Specifically, the Trainer Councils:

1. Assess the effectiveness of the TATS model and pinpoint where additional work is needed.
2. Share training issues and concerns with other trainers and problem-solve.
3. Meet with trainees, design teams, facilitators, and supervisors to gather important feedback.
4. Set requirements for and monitor the TATS Trainer Certification Program.
5. Work on case studies (or observe trainers during delivery of OJT) in order to achieve inter-rater reliability among trainers; i.e., to assure that (1) two or more trainers would evaluate the same performance in the same way, and (2) the same trainer would evaluate similar performance in different trainees in the same way.
6. Review and document performance measurements.
7. Provide a sounding board for trainee issues and concerns.
8. Assist the design team with the on-site verification of modules to assure that tasks requiring more than one technician are adequately addressed and coordinated.

5.1.6. Step 6 – tryout, evaluate, and modify

Each module is verified on-site at least twice: first by a trainee with a trainer, and second by at least one member of the approval team. Modules should be verified using the same three-step job instruction training procedure as used during actual training (see step 8). This verification process can serve as 'on-the-job' training for the TATS trainers.

TATS encourages any additions, deletions, or corrections. Anyone may suggest changes, including the trainees. This is also the time to make sure that the performance standards are adequate and that both trainers and trainees share a clear understanding of what counts as successful task completion.

5.1.7. Step 7 – set-up maintenance plan and audit

Teams distribute manuals in work centers for use as resource guides. Everyone, from line managers to operating staff, has some ownership of the system. To keep the manuals up-to-date, each manual includes copies of change sheets. Change sheets are simple forms for identifying modules and the changes required. One member of the workforce is assigned to serve as an administrative coordinator to handle the records, forms, manual updates, etc.

The facilitator schedules annual audits to assess the status of TATS in the particular work area. The audit is a checklist evaluation of critical areas of the process. Information is obtained primarily through individual and group interviews with the trainers, trainees, design teams, approval teams, and supervisors. During this evaluation the facilitator looks for signs of program obsolescence, identification of new training needs, opportunities to streamline the operation to make it more cost-effective, and organizational changes that impact training. Results of these evaluations at three airlines revealed the following:

1. In many cases, there is no existing maintenance manual procedure for particular tasks identified in the task analysis, and teams created controlled manuals or procedures addressing these tasks in addition to writing the OJT modules.

2. Incorrect information in maintenance manuals was noted and corrected.
3. Some training modules need to be supported with technical training courses not yet in existence.
4. Occasionally training modules are no longer needed due to obsolescent equipment or outdated procedures, but several new modules are needed because of new equipment and automated processes.
5. Communication and organizational issues involving workload management are impacting performance and successful use of the OJT modules. These issues include poor communication and delineation of task responsibility between individuals, teams, and shifts, support organizations, and manufacturers.
6. More basic skills modules are needed as prerequisites to the normal OJT. Many technicians do not have these skills when they are hired by the airlines.

As a response to these findings, a human factors checks and balances instrument has been developed by one airline as a way to uncover these issues up front in the task analysis and incorporate the solutions directly into the training modules themselves where appropriate, especially in the areas of communication and workload management.

5.1.8. Step 8 – start training

The task analytic training system incorporates traditional job instruction training techniques using a three-step training procedure. First, the trainer demonstrates the skill to the trainee. Next, the trainer coaches the trainee through the elements of the task while the trainee performs them. Third, the trainee does the task without coaching. Both trainer and trainee discuss results afterwards.

Trainees are then encouraged to practice the new skills until they feel comfortable with them. A general rule of thumb is to allow trainees an hour of practice for every half hour of training. An advantage of the typical two-column format used for the modules is that the actual time spent by the trainer is minimized. Generally, once through the module using the three-step job instruction training procedure is sufficient. The trainee can then take the module and practice until competent.

At the conclusion of training, evaluation questionnaires are given to both trainees and trainers. The questions are open-ended to solicit as much spontaneous information about the training content as well as training implementation as possible. Some teams have also developed attitude surveys to show the positive results from using the system. The facilitator compiles evaluation data, keeping data confidential, and together with the design team and supervisor, plans any system modifications.

5.2. Putting all eight steps together

The eight steps in the process do not necessarily occur sequentially. There is normally considerable overlap. Teams usually work on the project plan, training implementation plan, maintenance/audit plan, and verify modules on-site while the module writing phase is going on.

It is convenient to think of the overall model as consisting of two processes: the module development process and the planning process.

The module development process comprises Steps 2, 4, 6, and 8. The planning and maintenance process consists of Steps 1, 3, 5, and 7. Checklists are used by the teams in developing and implementing the project plan, the training implementation plan and the maintenance/audit plan.

The TATS Implementation Chart, Fig. 5, shows the three tracks to follow for program

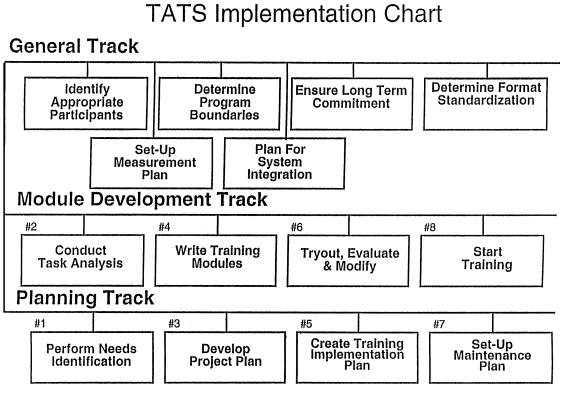

Fig. 5. TATS implementation chart. TATS implementation follows three basic tracks: the general track, the module development track, and the planning track.

Table 1
Key Personnel – Roles and Responsibilities

Design team:
(1) Conduct task analysis
(2) Create and implement a project plan
(3) Write training modules (with performance objectives)
(4) Verify modules on-site
(5) Conduct workforce overviews
(6) Obtain input from other workers
(7) Select approval team
(8) Schedule periodic progress reviews with supervision

Approval team:
(1) Meet with design team to be briefed on responsibilities
(2) help design team verify modules on-site
(3) meet with design team for TATS overviews
(4) approve modules, suggesting alternatives when appropriate

Facilitator:
(1) perform needs identification and discuss TATS process with workforce
(2) attend all design team meetings and work to build team cooperation, suggest alternatives, direct discussion, and help resolve conflict
(3) write on flip chart so that everyone can see
(4) teach design team how to:
write measurable objectives
write training modules
verify modules on-site
(5) administer evaluation questionnaires and compile data
(6) schedule and perform annual maintenance audit

Administrator:
(1) copy modules from flip chart for design team review
(2) ensure that modules are typed and maintained in an organized manner
(3) coordinate additions, deletions, and/or corrections
(4) keep manuals up-to-date and coordinate paperwork

Trainer:
(1) serve on the design team if possible
(2) assist in module on-site verification
(3) maintain "hands-on" experience with modules
(4) help keep midules up-to-date
(5) conduct evaluation pre-meetings with trainees
(6) prepare for training sessions and conduct training
(7) appraise and document performance
(8) meet with supervision when appropriate
(9) assist with module modification and monitor trainees' progress

implementation: (1) the general track (2) the module development track, and (3) the planning track. The general track is critical for program success and requires management leadership and support. For teams to be successful, there must be a central focal to serve as TATS coordinator as well as senior and mid-level management who are committed to the program.

6. Summary and conclusions

By the nature of its design, TATS provides a highly structured and disciplined OJT program that is on-going. Once the technicians see the potential of the system, there is literally no end to the number of tasks they decide to work on. They get involved not only with the tasks themselves and the subsequent training, but begin to identify and solve other issues that interfere with work performance such as information transfer during shift turnovers and parallel flows of activities. Implementing training systems that develop knowledge and skills among operational personnel consistent with organizational objectives and operating procedures that are compatible with human capabilities and limitations is fundamental to reducing maintenance error. Currently TATS is evaluated subjectively by the recipients of the program. Future research may yield data to support the system's claims of higher output in terms of productivity, quality and reduction of error (see Table 1).

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